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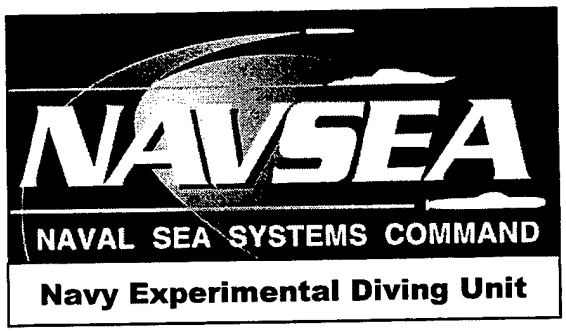

EVALUATION OF SCUBAPRO "SUPERHAWK" BUOYANCY COMPENSATOR

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19. ABSTRACT: **NEDU was tasked to conduct a survey of commercially available buoyancy compensators (BCs) and perform testing to determine which BC perform satisfactorily. Buoyancy compensator evaluation was conducted in three phases. Phase I included receipt inspection of the buoyancy compensator, technical review of the manufacturer-supplied documentation (instructions / repair manuals), diver orientation, and Test Pool Evaluation (surface floating attitudes if BCs were used as life jackets). No failure mode analysis was conducted. Phase II consisted of buoyancy / lift capacity testing in the OSF at 190 fsw. Phase III consisted of manned dives in the Gulf of Mexico to test diver buoyancy control and operational characteristics.**

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INTRODUCTION

Navy Experimental Diving Unit (NEDU) is tasked[1] to conduct surveys of commercially available buoyancy compensators (BCs) and perform testing to determine which BCs perform satisfactorily in accordance with references (2) and (3). All buoyancy compensators that meet the above requirements will be candidates for recommendation to the Authorized for Navy Use (ANU) list. The purpose of this technical report is to determine if the ScubaPro "Superhawk" buoyancy compensator meets those requirements.

METHODS

GENERAL

Each BC was tested and evaluated in three different environments: Phase I, Bench Test; Phase II, Controlled Environment (Test Pool/Ocean Simulation Facility [OSF]); and Phase III, Open Ocean Diving. During bench testing, two qualified U.S. Navy divers evaluated each BC for completeness and adequacy of its maintenance manuals and technical documentation, skill levels that it required to perform routine repair and maintenance, and the operations of the integrated weight belt and all BC components. In a controlled environment each BC was tested and evaluated for buoyancy and lift capability. During open water dives each BC was used and evaluated by qualified U.S. Navy divers in both single and double SCUBA tank configurations to a minimum of 30 fsw (9.4 msw). The conversion for msw is in accordance with reference (3).

EXPERIMENTAL DESIGN AND ANALYSIS

All BCs tested were off-the-shelf items; three sizes were tested: medium, large, and X-large. The Task Leader or assigned representative was present during the setup and post-dive procedures for all BCs.

Phase I testing:

- Each model BC was evaluated by two qualified U.S. Navy divers for ease of operation and maintenance procedures.
- Average cost from five different suppliers was acquired.

Specific comments from evaluators were compiled and documented.

Phase II testing:

- All BCs of different sizes were tested to 190 fsw (59.4 msw) using the OSF. Each BC was fully inflated three times in both single and twin configurations, and the average lift capacity was recorded.

Phase III testing:

- All BCs of different sizes were evaluated during a series of open water dives conducted at a minimum depth of 30 fsw. Divers completed a human factor

questionnaire after each dive. A set of statistics describing the responses and specific comments were complied.

EQUIPMENT AND INSTRUMENTATION

No special or proprietary tools were required to perform routine maintenance or repair on the BCs.

a. Phase I: During bench testing the following equipment was used:
   (1) Fully charged SCUBA bottle and an approved regulator (used to supply low-pressure air to perform equipment checks)
   (2) Manufacturer's instructions and maintenance manual
   (3) Miscellaneous hand tools and adapter fittings
   (4) Weights (soft or molded)

b. Phase II: During OSF and open ocean testing the following equipment was used:
   (1) Calibrated spring scale (Model #895, Viking Scale, Shubuta, MS), 0 to 50 pounds (0 to 22.68 kg)
   (2) Lanyards, spinnaker shackles, and weight as appropriate to anchor the BCs to the deck in the wet chamber or on top of the bridge span
   (3) Fully charged SCUBA bottle and an approved regulator (used to supply low-pressure air)
   (4) Personnel as required
   (5) Weights

c. Phase III: During at-sea testing the following equipment was used:
   (1) Fully charged SCUBA bottle, approved regulator, and all other personal diving equipment needed to perform a SCUBA dive
   (2) Personnel as required
   (3) At-sea diving platform

PROCEDURES

BC evaluation was conducted in three phases: (1) Receipt inspection and technical review of manufacturer-supplied documentation, (2) OSF wet chamber evaluation (buoyancy/lift capacity at 190 fsw), and (3) Open water dives to test buoyancy control and operational characteristics.

a. Phase I testing began with a review of the following:
   (1) Completeness and adequacy of the maintenance manuals and technical documentation
   (2) Requirements for special or proprietary tools
   (3) Skill levels required to perform routine repair and maintenance
   (4) Operation of the integrated weight system
   (5) Operation and activation of all BC components
   (6) Ease of assembly from single tank configuration to twin tank configuration
   (7) Unit price

A technical documentation and operational function worksheet was completed by each qualified diver, and returned to the Task Leader.

b. Phase II Testing: Buoyancy/lift capacities of the units were tested in the OSF wet chamber at a depth of 190 fsw. All divers participating in the study were required to familiarize themselves with the contents of the user's manual, including the location of controls on the BC and donning procedures.

A calibrated Viking Scale model #895 was attached to the deck grating of the OSF or shackled onto the top of a sunken bridge span to measure buoyancy. Each BC was attached to the scale and tested. The buoyancy was measured and documented; at a minimum, each BC was required to provide 10 lbs. of positive lift, as outlined in reference (2). Each BC was also tested for leaks at depth.

c. Phase III Testing: Manned open water dives were conducted to a minimum depth of 30 fsw to determine each BCs swim characteristics. Results were documented using a diver's questionnaire.

RESULTS

PHASE I

The documentation that the manufacturer supplied on the use and technical specifications of the BC, the exploded views/diagrams of it, and the service and parts for it was unsatisfactory. No parts list or technical specifications were included within the supplied buoyancy compensator manual, but these documents were available from the manufacturer upon request. There are requirements for special proprietary tools for major adjustments of the waist band, and a special banding kit is necessary for installing and removing of twin tanks. Skill levels required to perform routine maintenance should be those of at least a Second-Class Diver. The weights of the integrated weight system were secure, and it was easy to operate the release mechanism and reinstall them for redeployment. All BC components were easy to operate and activate. There were minor difficulties assembling the single tank configuration to the twin tank configuration.

The manufacturer's suggested cost per unit (Medium – X-Large) is $385.

PHASE II

All three sizes of the "Superhawk" in the single tank configuration averaged 35.2 lbf of positive lift at 190 fsw (see Table 1).

The measured buoyancy of the "Superhawk" BC was approximately 40.5% less than the 46 lbf quoted by the manufacturer for all bladder sizes. However, that difference might be attributed to differing test conditions, procedures, or depths.

In the twin tank configuration the three sizes of the "Superhawk" averaged 37 lbf of positive lift at 190 fsw (see Table 1).

The measured buoyancy of the "Superhawk" BC was approximately 41.3% less than the 46 lbf quoted by the manufacturer for all bladder sizes. This difference might be attributed to differing test conditions, procedures, or depths.

PHASE III

During the manned evaluation of the ScubaPro "Superhawk," 13 divers tested the buoyancy compensator in both tank configurations to depths ranging from 30 to 130 fsw. The BC scored ratings of 5.02 in the single tank configuration and 5.22 in the twin tank configuration on a scale of 1 – 6, with 4.0 being the minimum mark for an overall acceptable score.

CONCLUSIONS

During testing, two major items of note were encountered. First, in accordance with the manufacturer's technical manual the cylinder band strap must be wet prior to installation of the single configuration tank. If this was not done, the bottle tended to slip down and out of the BC, and this could cause the diver's air supply to be lost.

The second item noted was the difficulty shifting the BC from single tank configuration to twin tank configuration. In order to install the twin tank configuration, tools and a special banding kit are needed. Once the BC is in the twin tank configuration, tools are required to remove the tanks from the BC for charging with air or for any other necessary maintenance.

The buoyancy compensator "Superhawk" has an integrated weight belt system that the diver can remove and ditch from the buoyancy compensator in case of emergency[4]. Either side or both sides of the system can be ditched to regain proper buoyancy control. We suggest that only one side be dumped at a time, to allow the diver to see if proper buoyancy can be regained. If not, the other side may be ditched. This system is easy to use and easy to reinstall onto the buoyancy compensator. The weight module pockets are designed to hold a maximum of 16 lbs. of molded or soft weights in each pocket for a total onboard weight capacity of 32 lbs.

RECOMMENDATIONS

Based on the testing and evaluation in accordance with reference (3) and reported in Tables (1) and (2), the ScubaPro "Superhawk" (P/N: Medium 22.121.301 M, Large 22.121.401 L, and Extra Large 22.121.501 XL) is recommended for continued use. No surface floating attitude testing was conducted; therefore, we do not recommend that this buoyancy compensator be used as a life preserver.

Table 1. ScubaPro "Superhawk" Buoyancy Compensator Pull Test Data in Single and Twin Tank Configuration

ScubaPro "Superhawk" Single Tank Configuration					
NO.	NOMENCLATURE	BC #	PULL TEST WEIGHT (LBF)	DEPTH	INFLATION METHOD
1	ScubaPro "Superhawk"	M	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
2	ScubaPro "Superhawk"	L	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
3	ScubaPro "Superhawk"	XL	35.2 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
ScubaPro "Superhawk" Double Tank Configuration					
NO.	NOMENCLATURE	BC #	PULL TEST WEIGHT (LBF)	DEPTH	INFLATION METHOD
1	ScubaPro "Superhawk"	M	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
2	ScubaPro "Superhawk"	LG	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE
3	ScubaPro "Superhawk"	XL	37 LBF	190 FSW	LP WHIP FROM SCUBA BOTTLE

Table 1. Each size BC was tested to 190 fsw (59.4 msw) using the OSF. Each BC was fully inflated three times in both single and twin configurations and the average lift capacity was recorded.

Table 2. Human Factors Evaluation of the ScubaPro "Superhawk" Buoyancy Compensator in Single and Twin Tank Configuration

ScubaPro "Superhawk" Single Tank Configurtion										
	#8	#9	#10	#11	#12	#13	#14	#15	#16	
QUESTIONNAIRE #	COMFORT	MOBILITY	DONNING & DOFFING	NEUTRAL BUOYANCY	LOCATION OF CONTROLS	OPERATING CONTROLS	WATER DRAG	COMFORTABLE DIVING	OVERALL RATING	AVERAGE
1	6	6	6	6	6	6	5	6	6	5.89
2	5	5	5	5	5	5	4	5	5	4.89
3	6	6	6	6	6	6	5	5	5	5.67
4	5	5	5	5	5	5	5	5	5	5.00
5	5	1	5	5	5	5	5	6	5	4.67
6	5	6	6	5	4	5	5	6	5	5.22
7	6	5	6	5	6	6	5	6	6	5.67
8	6	6	5	5	4	5	4	5	5	5.00
QUESTION AVERAGE	5.50	5.00	5.50	5.25	5.13	5.38	4.75	5.50	5.25	5.25
								OVERALL AVERAGE		5.25

ScubaPro "Superhawk" Twin Tank Configurtion										
	#8	#9	#10	#11	#12	#13	#14	#15	#16	
QUESTIONNAIRE #	COMFORT	MOBILITY	DONNING & DOFFING	NEUTRAL BUOYANCY	LOCATION OF CONTROLS	OPERATING CONTROLS	WATER DRAG	COMFORTABLE DIVING	OVERALL RATING	AVERAGE
1	5	6	6	6	4	4	6	6	5	5.33
2	5	5	5	6	5	4	5	6	5	5.11
3	6	6	6	5	5	4	6	6	5	5.44
4	5	5	5	6	5	4	5	6	5	5.11
5	4	4	5	4	4	4	4	4	4	4.11
QUESTION AVERAGE	5.00	5.20	5.40	5.40	4.60	4.00	5.20	5.60	4.80	5.02
								OVERALL AVERAGE		5.02

Table 2. A series of evaluation dives completed per BC, per tank configuration. All open water dives were conducted to a minimum depth of 30 fsw (9.4 msw). Divers completed a human factors questionaire after each dive. A set of statistics describing the responses and specific comments were compiled. The BCs were scored on a 1 – 6 scale with 4.0 being the minimum mark for an overall acceptable score (1 = poor, 4 = adequate, 6 = excellent).

REFERENCES

1. Naval Sea Systems Command, Task Assignment 98-10, *Commercial Diving Equipment Test and Evaluation*, Dec 97.
2. C. J. Zanoni, *Procedure for the Evaluation of Commercially Available Buoyancy Compensator's (Unmanned/Manned),* NEDU TP00-10, Navy Experimental Diving Unit, September 2000.
3. Naval Sea Systems Command, *U.S. Navy Diving Manual, Vol. #5*, Rev. 4, NAVSEA SS521-AG-PRO-010, 20 Jan 99, Ch. 7-2.3.4, pp. 7-9.
4. Naval Sea Systems Command, *Diving Equipment Authorized for Navy Use*, 00C/3112 of 12 Mar 01.
5. Scubapro, *Buoyancy Compensators Owner's Manual,* El Cajon, Ca. Owners Manual 2000.